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Landscape Evolution at Shihmen Reservoir Watershed, Northern Taiwan

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Modern topography in Shihmen Reservoir catchment, northern Taiwan is dominated by transient features such as convex slope breaks, inner gorges, terraces, paleosurfaces and knickpoints. They suggest that incision has propagated as waves through the catchment. The topography and river network in the Shihmen Reservoir catchment were analyzed using a 20-m DEM. Three pronounced convex breaks in hillslope gradient (BH, BL1 and BL2, in descending altitude) are identified, which is indicative of at least three transient waves of incision. The knickpoints have a wide range of elevation (between 500m to 3000 m) and could be grouped into three, corresponding to three slope breaks, KP_{BH}, KP_{BL1} and KP_{BL2}, by relative heights above tributary mouths.

Normalized channel steepness indices for channel extents above the knickpoints vary strongly downward stream and show highest steepness values below the knickpoints nearest to the tributary mouths. Basin-averaged hillslope gradient increases from paleosurfaces to lower dissected slopes. Dissection in inner gorges makes steeper hillslopes (avg. 39.8°) and channels with higher normalized channel steepness indices (two times higher on average in channel segments just below knickpoints than the segments above KP_{BH} . Numerous numbers of small landslides occur on side slopes of inner gorges in response to incision. Many huge gravitational slope deformations affect plaeosurface above the highest slope break (BH). These results show that incision of gorges and subsequent slope movements are the dominant processes during the landscape evolution.

To reveal the landscape evolution and basin-averaged denudation rates in the long-term, we determined an absolute timescale by surface exposure dating using terrestrial cosmogenic nuclides. Samples are from ridge-top bedrock, boulders with a few meters in diameter on ancient deep-seated landslide deposits, terrace deposits, and abandoned fluvial deposits near wind gaps. The ridge-top bedrock provides minimum age of ~140 ka, which could represent the formation age of the paleosurface. Surface exposure ages of the boulders range ~120 to 140 ka, suggesting the occurrence of deep-seated landslides around the paleosurface at these ages. These ages may also indicate the timing of the 'phase I' incision that formed BH in the upstream catchment. Tectonic activity may be responsible for the initiation of the 'phase I' incision. Gravel-capped terrace with a relative height of 270 m from the current trunk river bed above the rim of BL1 at the lower quarter of the catchment has been dated to as ~13 to 15 ka, indicating the 'phase II' incision rate of 20 mm a^{-1}. The rapid incision might be attributed to sea-level lowering during last glaciation and is enhanced by climate forcing such as increasing monsoonal precipitation during the last glacial-to-interglacial transition. The BL2 associated with the 'phase III' incision appears to grade to terraces traced several tens to a hundred meters above the trunk bed, however, their ages are yet unknown. Gravel ages (90 ka and ~14 to 15 ka) in wind gaps indicate that propagation of incision waves capture rivers of nearby river systems in some places.